

3204-01

## TITLE: ADHESION PROMOTERS FOR GLASS-CONTAINING SYSTEMS

BACKGROUND OF THE INVENTION

The present invention relates to aqueous mixtures of additives which  
5 provide improved adhesion of adhesives to glass and improved dispersion of  
glass fibers.

Various fibrous or particulate materials, including glass, glass  
microspheres, glass filament, glass powders and especially chopped fiberglass,  
are used in various products as a filler to reduce weight or add strength to  
10 products. Examples of these applications are the production of nonwoven mats,  
filter media, gaskets, roofing mats, roofing shingles, cementitious building  
materials, molded fiberglass parts, and automotive and marine body fillers.

Often fiberglass is used in an aqueous system, and during use these fibers  
can settle out of or float on top of liquid solutions, which leads to problems in  
15 production. Many fibers, including glass and especially fiberglass, are not  
normally wetted by water very well and have the tendency to clump together, or  
not disperse well, when added to an aqueous system. Surfactants are used to  
enable liquids to wet the fibers by lowering the surface tension, but the  
surfactants may not suspend or separate the individual fibers. Thickeners, for  
20 example, guar gum, are used to increase the viscosity of a water/fiberglass  
system to help suspend the fiberglass. Frequently, constant agitation and/or high  
shear is applied to keep the fiberglass homogenously suspended.

The production of a homogenous suspension of fiber in water will  
improve the handling and performance of fiber, allowing more uniform coverage  
25 and accurate placement of fiber in applications where fiber is used to give  
strength and fill to products. Reducing the need for continuous mixing or high  
shear is also beneficial from an energy and convenience standpoint.

Moreover, adhesives and/or binders (e.g., resins) used to make various  
glass-containing products often exhibit only marginal adhesion to the glass. The  
30 binders or adhesives are typically used to help maintain the integrity of the final  
glass-containing product, so improving their adhesion to glass can improve the  
final glass-containing product by making it stronger and more durable. In one  
aspect the present invention improves the interaction of various binders and  
adhesives to a glass surface. It is believed that the present reactive sulfonates  
35 can interact with the glass surface via their sulfonic acid-derived functionality

and with the adhesives or binders via the remaining portion of the molecule, thereby tying the glass surface to the binder thus improving adhesion.

The invention disclosed herein includes a dispersion additive system that promotes the wetting of glass, whether in fiber form, particulate form, or other form, e.g., plate glass, by liquids. When applied to fiber glass, it helps separate the fiber bundles into individual fibers without the need for high shear and suspends the separated individual fibers. The unbundling and dispersion of the fiber filaments by these additives leads to good infiltration of resins into the fiber as well as improved adhesion of the resin to the fiber. Good contact, infiltration, and adhesion of resins to glass promoted by these additives leads to a stronger bond between the resin and glass and increases the strength of the glass/resin system. When applied to glass in other forms, such as plate glass, the materials of the present invention promote adhesion of resinous coating materials to the glass.

The present invention, therefore, in one aspect, solves the problem of providing improved dispersion of glass fibers, e.g., chopped fiber glass, which may otherwise need high shear or continuous stirring to disperse, separate and suspend them. It accomplishes this by chemically dispersing the glass particles or fibers. The invention also modifies the surface of the glass, in whatever form, to improve wetting and adhesion.

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#### SUMMARY OF THE INVENTION

The present invention provides a method for providing a resinous coating material on glass exhibiting improved adhesion thereto, comprising

- (a) supplying to said glass a coating composition comprising
  - (i) a reactive sulfonic acid-derived compound; and
  - (ii) a resinous coating material.

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In another embodiment, the invention provides a method for imparting improved adhesion of a resinous coating material to glass, comprising:

- (a) coating the glass with a first coating composition comprising a reactive sulfonic acid-derived compound; and

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- (b) applying, to said coated glass, a resinous coating material.

The invention further provides a glass composition comprising:

- (a) a glass substrate and
- (b) a coating, comprising
  - (i) a reactive sulfonic acid-derived compound; and
  - (ii) a resinous coating material.

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It likewise provides a glass composition comprising:

- (a) a glass substrate with

(b) a coating comprising a reactive sulfonic acid derived compound;  
said glass composition exhibiting improved adhesion ability to a resinous  
coating material that may be additionally applied.

As otherwise expressed, the present invention provides a composition  
5 suitable for wetting, dispersing or suspending fiber in aqueous solutions,  
comprising the following components:

(a) an aqueous liquid carrier, optionally 100% water and optionally  
containing resins or co-solvents such as alcohols;

10 (b) glass, such as fiberglass, more preferably chopped  
fiberglass;

(c) an acid based wetting / dispersing / suspension / adhesion aid,  
preferably a sulfonic acid based additive, more preferably a 2-acrylamido-2-  
methylpropane sulfonic acid based additive;

15 (d) optionally a buffer to keep the pH of the fiberglass-containing  
solution in a desired pH range, e.g., 2-6;

20 (e) optionally a water based (i.e., water reducible, e.g., soluble or  
dispersible) resin used to bind the fiberglass together, which resin can be urea-  
formaldehyde, phenol formaldehyde or melamine formaldehyde, latex binders  
such as acrylic latex, styrene butadiene rubber latex, polyester acrylic latex,  
styrene acrylic latex, or poly vinyl acetate based or any combination thereof.

The invention thus also includes a method to contact fiberglass with  
additives, comprising the following steps:

(A) dissolving or combining an acid based additive in water or into  
an aqueous liquid carrier system or resin system;

25 (B) adding the fiberglass to the additized water or resin;

(C) mixing the fiberglass solution; and optionally thereafter

(D) using the treated fiberglass or fiberglass resin system in a  
customer specific application.

30 Alternatively, the fiberglass can be treated with an aqueous solution of the  
acid based additive, isolated from the solution and then used in the customer  
specific application.

The invention encompasses the use of the components (a), (b) and (c) in  
slurries for preparing fiberglass matting, as well as composition comprising  
components (b) and (c) as such and as further used in applications hereinafter  
35 described.

## DETAILED DESCRIPTION OF THE INVENTION

Various preferred features and embodiments will be described below by way of non-limiting illustration.

One component of the present invention, an optional component (iii) which can be used when the inventive formulation is applied in a liquid form, is a liquid carrier, preferably an aqueous liquid carrier, more preferably water, such as distilled, deionized, or tap water. The source of the water is not normally critical to the present invention. Additionally, the aqueous liquid carrier may comprise a co-solvent. Typical co-solvents include alcohols, acetone, dimethylformamide or combinations thereof. Alternatively, the liquid carrier can comprise solely the above co-solvents (i.e. without water).

When used as a slurry, the amount of component (iii) in the compositions of the present invention is generally 90% or more by weight, e.g., 99.9 or 99.5% to 50% by weight. Preferably the amount of component (iii) is 95% to 99%. In another embodiment, the amount of component (iii) is about 99%.

Alternatively, when the adhesive or coating composition of the present invention contemplated for application to a glass substrate that does not need to be suspended therein, it is possible to supply the components of the adhesive or coating composition in a form other than a solution or dispersion in an aqueous medium. For instance, a resin or binder (described below) may itself be in a fluid form in which other components can be dissolved or suspended. Alternatively, in some instances it is possible to apply the components in an appropriately mixed solid or powder form.

Another component of the present invention is glass. The glass can be present in various forms, including glass fibers (i.e., fiberglass) including milled fibers, chopped strand, roving, optical fiber yarn; fiberglass mat product; plate glass; glass particles; glass microspheres; and other various glass articles.

The amount of the glass component, when it is present in a slurry compositions, is generally 0.05% to 10% by weight of the slurry composition. Preferably the amount of the glass component in slurries is 0.1% to 5% or to 1% by weight.

Another component (i) is a sulfonic acid-derived compound. Specific examples of this type of component include 2-acrylamido-2-methylpropane sulfonic acid, salts thereof such as 2-acrylamido-2-methylpropane sulfonic acid sodium salt, 2-acrylamido-2-methylpropane sulfonic acid ammonium salt and amine salts, 2-acrylamido-2-methylpropanesulfonic acid fatty amine adducts or alcohol adducts, 2-acrylamido-2-methylpropane sulfonic acid oligomers, para

toluene sulfonic acid, methane sulfonic acid, taurines, sulfohydroxamic acids, sulfo-N-hydroxy succinimides, vinyl sulfonic acid, methallyl sulfonic acid, styrenesulfonic acid, and other sulfonated monomers, such as sodium vinyl sulfonate, sodium allyl sulfonate, sodium styrene sulfonate, sodium methallylsulfonate, sodium sulfophenyl methallyl ether, sodium allyl ether sulfonate, and 2-sulfoethyl methacrylate, acrylic acid – (3-sulfopropyl) ester and salts (such as the potassium salt) methacrylic acid-(3-sulfopropyl) ester and salts, (such as the potassium salt), itaconic acid-bis-(1-propylsulfonic acid-3-) ester and salts (such as the di-potassium salt), 3-allyloxy-2-hydroxypropanesulfonic acid and salts (such as the sodium salt).

When the sulfonic acid derived compound is employed to impart improved adhesion to glass, it is a reactive sulfonic acid derived compound. This means that the compound has an additional reactive functionality in the molecule, besides the sulfonic acid or sulfonate moiety. The additional reactive portion permits chemical reaction or interaction of the molecule with other molecules of the same or similar species, or with molecules of a resinous coating material, or with the glass substrate. A preferred reactive moiety is an olefinic double bond. Without intending to be bound by any theory, it is believed that the olefinic double bond of such preferred materials as 2-acrylamido-2-methylpropanesulfonic acid is capable of various addition reactions (whether spontaneous or catalyzed by acid, base, or radicals) to increase the interaction of the molecules among themselves (e.g., by in-situ oligomerization) or with corresponding sites on a resinous coating material. Many of the examples of component (i) set forth above contain an olefinic double bond, as will be recognized by those skilled in the art, and as such are believed to be especially suited for the adhesion applications of the present invention.

Certain suitable sulfonic acids can also be described as an unsaturated-hydrocarbylamido-alkanesulfonic acid or a salt thereof. The “hydrocarbylamido” moiety comprises a hydrocarbyl group with an amide functionality thereupon, through which linkage is made to the remaining alkanesulfonic acid moiety. Such a material can have the general structure

[hydrocarbyl]-CONH-[alkylene]-SO<sub>3</sub>H

As used herein, the term “hydrocarbyl” has a well-established meaning, namely, a group having a carbon atom directly attached to the remainder of the molecule and having predominantly hydrocarbon character. Examples of hydrocarbyl groups include hydrocarbon substituents, that is, aliphatic (e.g., alkyl or alkenyl) or alicyclic (e.g., cycloalkyl, cycloalkenyl) substituents, and aromatic-,

aliphatic-, and alicyclic-substituted aromatic substituents, as well as cyclic substituents wherein the ring is completed through another portion of the molecule (e.g., two substituents together form a ring); substituted hydrocarbon substituents, that is, substituents containing non-hydrocarbon groups which, in the context of this invention, do not alter the predominantly hydrocarbon nature of the substituent (e.g., halo (especially chloro and fluoro), hydroxy, alkoxy, mercapto, alkylmercapto, nitro, nitroso, and sulfoxyl); hetero substituents, that is, substituents which, while having a predominantly hydrocarbon character, in the context of this invention, contain other than carbon in a ring or chain otherwise composed of carbon atoms. Heteroatoms include sulfur, oxygen, nitrogen, and encompass substituents as pyridyl, furyl, thienyl and imidazolyl. In general, no more than two, preferably no more than one, non-hydrocarbon substituent will be present for every ten carbon atoms in the hydrocarbyl group; typically, there will be no non-hydrocarbon substituents in the hydrocarbyl group.

The sulfonic acid derived compound will preferably have a molecular weight of less than 700, preferably less than 500 or 300.

The amount of component (i), especially in slurry compositions of the present invention (i.e., when used to promote dispersion of glass fibers) does not have a particular upper limit, but may be up to 10%, 5%, 2%, or 1%; more generally it is 1 to 1000 or 10 to 500 parts per million by weight of the slurry. Preferably the amount of component (i) is 25 to 200 parts per million. More preferably the amount of component (i) is 50 to 175 parts per million.

Optionally an additive can be included to modify the pH of the solution or liquid which contacts the glass. The additive can simply be an acid or base such as H<sub>2</sub>SO<sub>4</sub>, HCl, or NaOH. Examples of this type of component include mixtures of 2-acrylamido-2-methylpropane sulfonic acid and 2-acrylamido-2-methylpropane sulfonic acid sodium salt, mixtures of 2-acrylamido-2-methylpropane sulfonic acid and 2-acrylamido-2-methylpropane sulfonic acid ammonium salt, mixtures of 2-acrylamido-2-methylpropane sulfonic acid and sodium sulfate, and mixtures of methane sulfonic acid and sodium hydroxide, mixtures of p-toluene sulfonic acid and sodium hydroxide. This component can be a buffer system which can be made from an acid and its conjugate base, e.g., phosphate carboxylate, or carbonate buffers. Thus, the system can be buffered by the proper selection of component (d). The resulting pH can be 1-11.

The amount of the pH adjusting component, if present in the compositions of the present invention, is generally 0.01 to 10% by weight of the entire composition. Preferably the amount is 0.1 to 5% by weight.

The composition described above can be prepared by adding the sulfonic acid derived compound to water and then contacting water with the glass, followed by shear and/or mixing, particularly if the glass is present as fiber glass to be dispersed in the aqueous medium. Alternatively, the fiber glass and water  
5 can be first contacted, and then the sulfonic acid derived compound added.

One component which is normally present is (ii) a resinous coating material suitable for coating on or adhesion to glass. This material is sometimes referred to or used as a binder. Specific examples of this type of component include phenol formaldehyde resins, urea formaldehyde resins, melamine  
10 formaldehyde resins, polyvinyl acetate resins including polyvinyl acetate resin, latex binders such as acrylic latex, polyvinyl alcohol resins, styrene butadiene rubber latex, acrylic or methacrylic resins such as polyester acrylic latex or styrene acrylic latex, epoxy resins, and/or mixtures of the above. Preferably the resins are soluble or dispersible in water or in another solvent so that they can be  
15 applied to the surface of the glass (particularly but not necessarily in fiber form) from solution or dispersion.

The amount of such a resin, if present in the liquid or aqueous compositions of the present invention, is generally 0.001% or 0.1 % or 0.25% by weight up to 1 % or 10% or 25% or even 50% by weight based on the amount of  
20 the liquid composition.

Other components which are conventionally employed in a fiberglass resin system are typically also present, or may be omitted. Among such components are antifoam agents, thickening agents, surfactants, adhesive resins, biocides, curing catalysts, and radical inhibitors.

25 The above components can be in the form of a fully-formulated adhesive or resin system or in the form of a concentrate within a smaller amount of water or resin concentrate. The relative weight ratio of sulfonic based additive to resin can be 0.1:99.9 to 50:50, or 0.5:99.5 to 10:90 or 1:99 to 5:95; in one embodiment it can be 2:98.

30 The steps in carrying out the method of the present invention can include the following, which are applicable particularly when the glass is present in the form of fibers to be dispersed:

(A) The sulfonic acid-derived compound is dissolved in water (or another liquid carrier system, e.g., an aqueous liquid carrier system) at an appropriate  
35 concentration (typically about 1% by weight). The temperature and mixing rate of the composition can be adjusted if necessary to completely dissolve the additive.

(B) A suitable amount of the glass, especially if in fiber form (e.g., 0.5 g) is added to the water/suspension aid mixture (e.g., 49.5 g). The addition of the sulfonic acid-derived compound and the glass fiber, to the liquid medium, can occur in either order.

5 (C) The glass and liquid medium are preferably mixed until mixed well. The mixing can be high or low shear, by hand shaking, mechanical stirrer, sonicator, lightning mixer, tumbling, or drum roller.

10 (D) The resulting mixture, especially a fiber glass suspension, is used as per the specific application. This may involve transport, filtration, water removal, mat making, or combining with other components such as resins.

15 Alternatively, the composition of the present invention can be applied as a surface coating or treatment or pre-treatment to glass that is not in a form which can be readily dispersed, for example, plate glass or a pre-formed fiber glass mat, or other glass articles as previously mentioned. In this embodiment, the method of the present invention can be carried out by the following steps:

(i) The sulfonic acid-derived compound is dissolved or dispersed in water (or the liquid carrier system) at an appropriate concentration (e.g., about 1% by weight). The temperature and mixing rate of the composition can be adjusted if desired to completely dissolve the additive.

20 (ii) A thin layer of the aqueous composition of (i) is coated onto the glass article. The coating process can be by any conventional process, including spraying, dipping, brushing, rolling, or curtain coating.

25 (iii) The coating layer of (ii) is dried, that is, at least a portion of the aqueous or other liquid component and other volatile components are removed, optionally by application of heat.

30 (iv) Thereafter a coating or film of resinous coating material (that is, a film-forming resin or binder) is applied to the glass. The resin may be applied from a solution or dispersion by conventional coating methods (spraying, dipping, brushing rolling, curtain coating), including removal of the liquid medium, e.g., by heating. Alternatively, it may be applied in a molten form, e.g., by extrusion. Or it may be applied by application of a pre-existing solid film or by application of particles in a powder coating process, to the coated surface of the glass, followed by conventional heating or other treatment, if desired, in order to assure intimate contact between the coating layer and the treated glass substrate.

35 As yet another alternative, the present invention can comprise the coating of a glass article with a coating or film of resin wherein the sulfonic acid derived

compound is admixed with the resin, typically in an aqueous medium. Such a process can include the following steps:

(i) The sulfonic acid derived compound is dissolved or dispersed in water (or the liquid carrier system, e.g., aqueous liquid carrier) at an appropriate concentration (e.g., about 1% by weight). The temperature and mixing rate of the composition can be adjusted if necessary to completely dissolve or disperse the additive.

(ii) The resinous coating material is dissolved or dispersed in the composition of (i), along with the sulfonic acid-derived compound. Appropriate mixing or heating may be applied to assure the desired degree of complete mixing. These steps (i) and (ii) can be conducted in either order, or the materials can be mixed simultaneously.

(iii) A thin layer of the (typically aqueous) composition of (ii), that is, containing both the sulfonic acid derived compound and the resinous coating material, is coated onto the glass article, using any convenient process, as described above.

(iv) The coating layer of (iii) is dried, that is, at least a portion of the liquid carrier (the aqueous component and other volatile components) is removed, optionally by application of heat.

Relative weight ratios of the sulfonic acid-derived compound and of the resin will typically be as indicated above. The inclusion of the sulfonic acid-derived compound along with the film-forming resin will typically lead to improved adhesion of the resin to the glass article.

The utility of the invention includes but is not limited to applications involving the manufacturing of nonwoven mats, gaskets, roofing shingles, floor tiles, fiberglass insulation, and cementitious building materials. The following is a brief description of the use of the technology in the aforementioned products.

A use for this invention is in the production of non-woven mats. A typical process to make non-woven mats is to introduce the fibrous glass material into a vessel such as a mixing tank. An aqueous medium, typically tap water, is added to the vessel. The sulfonic acid product earlier described is also added to the vessel. Optionally, a thickener, a binder (e.g., a film-forming resin), a biocide, and a defoamer can also be added to the vessel. An acid or base additive is added to the vessel, if desired, to adjust pH of the composition. The resulting composition is stirred and transferred (e.g. pumped) to a mat-forming device such as a porous moving line or another device with a mesh or porous base onto which the composition is deposited as the aqueous medium is removed

through the base (e.g. by vacuum). After the aqueous medium is pulled through the mesh, it can be recycled. The composition is then typically transported to a heater for further drying before being compressed and, typically, taken up on a roller for form a non-woven mat. Optionally, coatings may be applied to the mat prior to the drying step; that is, the mat may be treated as a glass article which can be further supplied with a resinous coating, as described above.

Another use for this invention is in the production of wet-laid gasket and filtration materials. The manufacture of wet laid fiberglass gasket and filtration media, for example, involves producing a slurry of chopped fiberglass suspended in a liquid, usually water, and then draining off the liquid phase of the slurry while it is in some sort of a form or mold. As the liquid is drained, the suspended fiberglass is uniformly deposited on the form or mold to yield a wet-laid fiberglass mat. The wet-laid fiberglass mat is then coated or bonded with resins, often polyurethanes, silicone, or thermoset resins like urea formaldehyde, melamine formaldehyde, phenol formaldehyde or polyvinyl acetate resin or mixtures thereof. The bonded fiberglass mat is then further processed to yield the finished gasket or filter media. The use of the present additives increases the uniformity of the fiberglass dispersion in the slurry. The better the fiberglass dispersion, the more uniform the wet laid mat, and thus the better the performance of the end product, since a uniform fiberglass mat is highly desirable. In addition, the present additives help suspend the fiberglass in the slurry, which reduces the amount of shear needed to process the slurry and also improves the handling properties of the fiberglass slurry. The present additives also increase the adhesion of the resins to the fiberglass, improving the gasket or filter product. Improved adhesion is also believed to arise from the improved inter-penetration of the resin into the fiberglass fibrils.

Another use for this invention is in the production of cementitious building materials, for example, fiberglass reinforced gypsum board. Some gypsum boards, such as fire resistant and thin core products, have fiberglass added to the formulation, typically at 1% or less weight of the board. The fiberglass adds strength without increasing combustibility. The manufacture of fiberglass reinforced gypsum board involves producing a slurry of chopped fiberglass suspended in a gypsum (calcium sulfate dihydrate) – water mixture. Other components of the gypsum mixture can be wax emulsions, other fillers such as vermiculite, and siloxanes. The fiberglass-containing gypsum mixture is then applied to sheets of craft paper, formed into the appropriate shape, and cured, by heating and driving off the water, to produce the final product. The

present additives can be added directly to the gypsum – water mixture or to wax emulsions. Alternatively, the fiberglass can be pretreated with the present additives and then used in the production of fiberglass reinforced gypsum board. The fiberglass pretreatment can be effected by making a slurry of chopped 5 fiberglass in water containing the dispersion additives. The additized water is then removed, leaving the treated fiberglass. The additized water can be reused to treat virgin chopped fiberglass. Alternatively, the fiberglass can be treated by being dipped or pulled through a bath containing water and the present additives. The treated fiberglass can then be utilized in the same way untreated fiberglass is 10 used in this gypsum board application, optionally including reslurrying in water, as well as in other applications. The use of the present additives in this gypsum board application increases the dispersion and suspension of the fiberglass into the gypsum material. The better the fiberglass dispersion, generally the better the strength and performance of the end product, since a homogenous dispersion 15 of fiberglass within the gypsum board is highly desirable.

This invention can also be used in fiberglass insulation material. The manufacture of fiberglass insulation batting involves coating spun fiberglass with a urea formaldehyde, melamine formaldehyde, phenol formaldehyde, acrylic thermoset, or polyvinyl acetate resin or mixtures thereof. The resin coating 20 maintains the shape of the fiberglass insulation during manufacturing, shipping and final use. During manufacture, shipping and installation, the resin can chip and/or break free of the fiberglass, adversely affecting the performance of the insulation. The use of the present additives increases the adhesion of the resins to the fiberglass, improving the coated fiberglass product. Improved adhesion also 25 arises from the improved inter-penetration of the resin into the fiberglass fibrils. In addition, using this invention may enable fiberglass insulation manufacturers to use less resin than is currently used, taking advantage of the increased adhesion to reduce material cost. During use for fiberglass insulation applications, the spun fiberglass can be dipped into or pulled through an additive containing water bath. 30 The treated fiberglass can then be processed in the usual way. Alternatively, the additive can be added to the resin system used to bind the spun fiberglass. In this case, the adhesion additive is added to the resin system in proportions to deliver about 1% wt active additive in the final resin.

This invention also finds utility in the manufacture of roofing shingles 35 and other roofing materials. During roofing shingle manufacture, a fiberglass mat is typically made from chopped, spun, or strand fiberglass. The mat can be made by taking an existing fiberglass mat and coating it with a urea

formaldehyde, melamine formaldehyde, phenol formaldehyde, or polyvinyl acetate resin or mixtures thereof. Alternatively the fiberglass can be mixed with a urea formaldehyde, melamine formaldehyde, phenol formaldehyde or polyvinyl acetate resin or mixtures there of after which the resin / fiberglass mixture is cast as a mat ready for further use. The mat is then further processed to make the finished asphalt roofing shingles or rolled roofing material. The further processing can involve curing the fiberglass mat with heat, the addition of asphalt, aggregate and other additives to the mat which ultimately makes up the final product. The asphalt can be added with or without the use of any additional resin. The fiberglass mat is used to add strength to the product. The inclusion of the invented compound increases the strength of the resultant fiberglass mat, which thus improves the final product. The increase in strength is believed to result from the enhanced adhesion of the resins to the fiberglass and from the improved inter-penetration of the resins into unbundled fiberglass fibrils.

In the manufacture of fiberglass containing roofing materials, the fiberglass can be dipped into or pulled through an additive-containing water bath. The treated fiberglass can then be processed in the usual way. Alternatively, the additive can be added to the resin system used to bind the roofing material product. The adhesion additive is added to the resin system in proportions to deliver 1% wt active additive in the final resin. The treated mat is then further processed to make the finished asphalt roofing shingles or rolled roofing material.

Further information on fiberglass mats, the method of their manufacture, and their uses, is found in U.S. Patent 6,084,021

25 Examples 1 – 11: Suspension of Fiber glass

Example 1:

Five grams of 2-acrylamido-2-methylpropanesulfonic acid and 44.5 grams of tap water are added to a 60 mL (2 ounce) screw capped glass jar. The solution is mixed by hand to form a clear colorless solution. To this solution, 0.5 grams of chopped fiberglass is added. The chopped fiberglass and aqueous solution are shaken by hand for 1 minute. The fiberglass is immediately dispersed and suspended.

Example 2:

The procedure referenced in Example 1 is repeated except using distilled water in place of tap water. The fiberglass is immediately dispersed and suspended.

Example 3:

Five grams of para-toluene sulfonic acid and 44.5 grams of deionized water are added to a 60 mL (2 ounce) screw capped glass jar. The solution is mixed by hand to form a clear colorless solution. To this solution, 0.5 grams of 5 chopped fiberglass is added. The chopped fiberglass and aqueous solution are shaken by hand for 1 minute. The fiberglass is dispersed and suspended over 5 minutes (that is, the individual fibrils within the fiberglass bundles become separated and dispersed, although not immediately, yet within 5 minutes).

Example 4:

10 Five grams of 98% active concentrated sulfuric acid and 44.5 grams of tap water are added to a 60 mL (2 ounce) screw capped glass jar. The solution is mixed by hand to form a clear colorless solution. To this solution, 0.5 grams of chopped fiberglass is added. The chopped fiberglass and aqueous solution are shaken by hand for 1 minute. The fiberglass is immediately dispersed and 15 suspended but then settles after standing for 8 hours.

Example 5:

20 Five grams of 2-acrylamido-2-methylpropane sulfonic acid sodium salt and 44.5 grams of tap water are added to a 60 mL (2 ounce) screw capped glass jar. The solution is mixed by hand to form a clear colorless solution. To this solution, 0.5 grams of chopped fiberglass is added. The chopped fiberglass and aqueous solution are shaken by hand for 1 minute. The fiberglass is completely dispersed and suspended over a 24 hour time period.

Example 6:

25 Five grams of 2-acrylamido-2-methylpropane sulfonic acid ammonium salt and 44.5 grams of tap water are added to a 60 mL (2 ounce) screw capped glass jar. The solution is mixed by hand to form a clear colorless solution. To this solution, 0.5 grams of chopped fiberglass is added. The chopped fiberglass and aqueous solution are shaken by hand for 1 minute. The fiberglass is completely dispersed and suspended over a 24 hour time period.

30 Example 7:

35 Five grams of 2-acrylamido-2-methylpropane sulfonic acid and 44.5 grams of tap water are added to a 60 mL (2 ounce) screw capped glass jar. The solution is mixed by hand to form a clear colorless solution. To this solution, 0.5 grams of chopped fiberglass is added. The chopped fiberglass and aqueous solution are shaken by hand for 1 minute. The aqueous solution is then decanted from the treated fiberglass. To the decanted aqueous solution is added 0.5 grams of virgin chopped fiberglass. The chopped fiberglass and the decanted aqueous

solution are shaken by hand for 1 minute. The fiberglass is immediately dispersed and suspended.

Example 8:

5 Seven grams of a 70% active aqueous solution of methane sulfonic acid and 44.5 grams of tap water are added to a 60 mL (2 ounce) screw capped glass jar. The solution is mixed by hand to form a clear colorless solution. To this solution, 0.5 grams of chopped fiberglass is added. The chopped fiberglass and aqueous solution are shaken by hand for 1 minute. The fiberglass is dispersed and suspended over 5 hours and begins to settle after 3 days.

10 Example 9:

One gram of 2-acrylamido-2-methylpropane sulfonic acid and 48.5 grams of tap water are added to a 60 mL (2 ounce) screw capped glass jar. The solution is mixed by hand to form a clear colorless solution. To this solution, 0.5 grams of chopped fiberglass are added. The chopped fiberglass and aqueous solution 15 are shaken by hand for 1 minute. The fiberglass is immediately dispersed and suspended.

Example 10:

20 Two and a half grams of 2-acrylamido-2-methylpropane sulfonic acid, 2.5 grams of 2-acrylamido-2-methylpropane sulfonic acid sodium salt, and 44.5 grams of tap water are added to a 60 mL (2 ounce) screw capped glass jar. The resultant buffered solution is mixed by hand to form a clear colorless solution. To this solution, 0.5 grams of chopped fiberglass is added. The chopped fiberglass and aqueous solution are shaken by hand for 1 minute. The fiberglass is immediately dispersed and suspended.

25 Example 11:

30 Five grams of 2-acrylamido-2-methylpropane sulfonic acid homopolymer and 48.5 grams of tap water are added to a 60 mL (2 ounce) screw capped glass jar. The solution is mixed by hand to form a clear colorless solution. To this solution, 0.5 grams of chopped fiberglass is added. The chopped fiberglass and aqueous solution are shaken by hand for 1 minute. The fiberglass is immediately suspended.

*Fiberglass dispersion* - The fiberglass dispersion / suspension tests are run by adding 1% fiberglass to an aqueous solution containing the suspension aid. Initially the wetting characteristics are noted, for example, whether the glass sits atop the water or wets rapidly (initial wetting is desired). Next the glass and water sample is shaken by hand for 1 minute and let settle. This test

assesses whether the glass is separated into individual fiber and whether or not the fibers are suspended. Both properties are visually apparent.

The test results show that acidic additives give good dispersion and suspension. Of the acidic additives, sulfonic acid derivatives give better performance. Of sulfonic acid derivatives, 2-acrylamido-2-methylpropane sulfonic acid derivatives give better performance. Of the 2-acrylamido-2-methylpropane sulfonic acid derivatives, 2-acrylamido-2-methylpropane sulfonic acid gives the best result in fiberglass dispersion and suspension.

Examples 12 – 14: Adhesive systems

10    Example 12:

One gram of 2-acrylamido-2-methylpropane sulfonic acid is added to 9 grams of a fully formulated polyvinyl acetate resin emulsion product (CustomBond MPA-11™, manufactured by CP Adhesives) with mixing. To the treated resin is added 40 grams of chopped fiberglass. The resultant resin/fiberglass mixture is a system with good glass adhesion properties.

15    Example 13:

1 gram of 2-acrylamido-2-methylpropanesulfonic acid sodium salt is added to 99 grams of a fully formulated polyvinyl acetate resin emulsion product (Titebond™, manufactured by Franklin International) with mixing. The resultant mixture is an adhesive with good glass adhesion properties.

20    Example 14:

1 gram of 2-acrylamido-2-methylpropanesulfonic acid sodium salt is added to 99 grams of a urea formaldehyde resin emulsion product (manufactured by Dynea) with mixing. The resultant mixture is an adhesive with good glass adhesion properties.

25    Testing of several of the compositions described above is carried out by the following test procedures:

Examples 15 – 22 Adhesion.

30    *Adhesion Promotion* – The adhesion performance of a film of polyvinyl acetate resin or urea formaldehyde resin to glass is assessed by ASTM D-3359 procedures A and B. The procedures involved coating of a thin layer of aqueous solution of polymer onto a glass plate, followed by drying of the polymer to provide a film. A rating of 5 is the highest possible adhesion result and 0 is the worst possible result. The results show that the addition of 1% by weight of 2-acrylamido-2-methylpropanesulfonic acid and derivatives to the aqueous solution of polymer leads to improved adhesion of resin to the glass panel.

Ex.	Product	Adhesion (ASTM D3359B)
15	Polyvinyl Acetate Resin (PVA) baseline (comparative ex.)	1B
16	1 wt% 2-acrylamido-2-methylpropanesulfonic acid/99 wt % PVA	4B
17	1 wt% 2-acrylamido-2-methylpropanesulfonic acid, Na salt/ 99 wt .% PVA	5B
18	1 wt% 2-acrylamido-2-methylpropanesulfonic acid, ammonium salt/ 99 wt .% PVA	5B

Ex.	Product	Adhesion (ASTM D3359B)
19	Urea Formaldehyde (UF) Resin base line (comparative)	3B
20	1%wt 2-acrylamido-2-methylpropane sulfonic acid / 99% wt UF Resin	4B
21	1%wt 2-acrylamido-2-methylpropane sulfonic acid Na salt / 99% wt UF Resin	4B
22	1%wt 2-acrylamido-2-methylpropane sulfonic acid Ammonium Salt / 99% wt UF Resin	3B

#### Examples 23- 30 Resin Film Hardness

*Resin Film Hardness* - The film hardness of a film of polyvinyl acetate resin or urea formaldehyde is assessed by ASTM D-3363 Test. The hardness scale used in this test is, from softest to hardest coating: 6B, 5B, 4B, 3B, 2B, B, HB, F, H, 2H, 3H, 4H, 5H, 6H, 7H, 8H, 9H. The results show that the addition of 1% by weight 2-acrylamido-2-methylpropane sulfonic acid derivatives to the aqueous solution of polymer leads to improved hardness of the resin adhered on the glass panel.

Ex.	Product	Hardness (ASTM D3363)
23	Polyvinyl Acetate Resin (PVA) baseline (comparative ex.)	1H
24	1 wt% 2-acrylamido-2-methylpropanesulfonic acid/99 wt % PVA	5H
25	1 wt% 2-acrylamido-2-methylpropanesulfonic acid, Na salt/ 99 wt .% PVA	5H
26	1 wt% 2-acrylamido-2-methylpropanesulfonic acid, ammonium salt/ 99 wt .% PVA	5H

Ex.	Product	Hardness (ASTM D33639)
27	Urea Formaldehyde (UF) Resin base line (comparative)	3H
28	1%wt 2-acrylamido-2-methylpropane sulfonic acid / 99% wt UF Resin	9H
29	1%wt 2-acrylamido-2-methylpropane sulfonic acid Na salt / 99% wt UF Resin	9H
30	1%wt 2-acrylamido-2-methylpropane sulfonic acid Ammonium Salt / 99% wt UF Resin	8H

Examples 31 – 37 Fiber suspension, mat formation and strength

Example 31:

To 1700 liters of tap water is added, in no particular order, 150 mL Foam Blaster™ 381 (a commercially available anti-foam agent), 250 mL of a 50% by weight aqueous solution of a 2-acrylamido-2-methylopropane sulfonic acid sodium salt adjusted to pH 7, 0.18 kg of a commercial polyvinyl alcohol binder, and 500 mL of a commercial viscosity modifier. The above mixture is mixed using a circulation pump or paddle mixer to ensure homogeneity. The pH of this resultant solution is 7. To the above mixture is added 1.63 kg of 1.27 cm length “M” glass fibers from PPG. The resultant solution/fiberglass mixture exhibits good fiber dispersion properties.

Example 32:

Example 31 is repeated using similar glass fibers from Johns Manville. The resultant solution / fiberglass mixture exhibits good dispersion properties.

Example 33:

Example 31 is repeated except that 75 mL of the 50% by weight aqueous solution of a 2-acrylamido-2-methylpropane sulfonic acid sodium salt is used, along with 1.63 kg of 0.635 cm length “DE” fiberglass from Owens Corning. The resultant solution / fiberglass mixture exhibits good fiber dispersion properties.

Example 34:

Example 33 is repeated using 0.41 kg of 0.635 cm length “DE” fiberglass from Owens Corning and 1.22 kg of a “microglass” from Lauscha.

Example 35:

Example 31 is repeated except that the mixture is adjusted with sodium hydroxide to a solution pH of 10, prior to addition of the 1.63 kg of 1.27 cm length "M" glass from PPG. The resultant solution / fiberglass mixture exhibits good fiber dispersion properties.

5

Example 36:

Example 35 is repeated using 1.63 kilograms of 1.27 cm length "M" glass from Johns Manville. The resultant solution / fiberglass mixture exhibits good fiber dispersion properties.

10

Example 37:

Example 33 is repeated, but adjusting the pH to a value of 2 by adding 38 weight % aqueous hydrochloric acid prior to adding 0.41 kg of a 0.635 cm length "DE" fiberglass from Owens Corning and 1.22 kg of "microglass" from Lauscha. The resultant solution / fiberglass mixture exhibits good fiber dispersion properties.

15

Certain of the materials from Examples 31 – 37 are used to prepare wet-laid mats of fiberglass. The mats are prepared on commercial equipment, by pumping the dispersed fiberglass to a mat-forming line, where the fibers deposit onto a moving wire base as the water (containing a major portion of the polyvinyl alcohol binder and other additives) is pulled through the mesh by vacuum. The mat is then transported to a heater for drying before being taken up on a roller.

20

Table of Test Results<sup>a</sup>

Ex.	Thickness, mm (mils)	Density g/cm <sup>3</sup>	Tensile Strength N/m (Lbs/in)		Tear Strength grams		Mullen Burst strength kPa (Psi)
			MD	TD	MD	TD	
31	0.190 (7.5)	0.261	523 (3.10)	378 (2.16)	82	68	120 (18)
32 <sup>b</sup>							
33	0.305 (12.0)	0.164	890 (5.08)	853 (4.87)	51	43	100 (15)
34 <sup>c</sup>							
35	0.251 (9.9)	0.198	851 (4.86)	774 (4.42)	98	95	100 (15)
36	0.188 (7.4)	0.264	583 (3.33)	529 (3.02)	62	53	83 (12)
37	0.297 (11.7)	0.169	399 (2.28)	538 (3.07)	22	22	69 (10)

Notes:

- a. All strength results normalized to a mat of 50 g/m<sup>2</sup>. MD = machine direction; TD = transverse direction.
- b. No roll prepared or tested due to relatively poor web strength.
- 5 c. Relatively poor quality mat not tested; appears to result from relatively poorer dispersion.

10 The good strength results for the fiberglass mats are believed to result from the good fiber dispersion, good adhesion properties of the fibers and the resin/binder, or a combination thereof.

15 It is known that some of the materials described above may interact in a final formulation, so that the components of the final formulation may be different from those that are initially added. For instance, metal ions (of, e.g., a detergent) can migrate to other acidic sites of other molecules. The products formed thereby, including the products formed upon employing the composition of the present invention in its intended use, may not be susceptible of easy description. Nevertheless, all such modifications and reaction products are included within the scope of the present invention; the present invention encompasses the composition prepared by admixing the components described above.

20 Each of the documents referred to above is incorporated herein by reference. Except in the Examples, or where otherwise explicitly indicated, all numerical quantities in this description specifying amounts of materials, reaction conditions, molecular weights, number of carbon atoms, and the like, are to be understood as modified by the word "about." Unless otherwise indicated, each 25 chemical or composition referred to herein should be interpreted as being a commercial grade material which may contain the isomers, by-products, derivatives, and other such materials which are normally understood to be present in the commercial grade. However, the amount of each chemical component is presented exclusive of any solvent which may be customarily present in the 30 commercial material, unless otherwise indicated. It is to be understood that the upper and lower amount, range, and ratio limits set forth herein may be independently combined. As used herein, the expression "consisting essentially of" permits the inclusion of substances which do not materially affect the basic and novel characteristics of the composition under consideration.